

FORM PTO 1300  
(REV. 5-95)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371ATTORNEY DOCKET NUMBER  
1926-00069

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

09/701217

INTERNATIONAL APPLICATION NO.  
PCT/GB99/01671INTERNATIONAL FILING DATE  
27 May 1999PRIORITY DATE CLAIMED  
28 May 1998TITLE OF INVENTION  
GASIFIERS WITH NON RADIAL TUYERESAPPLICANT(S) FOR DO/EO/US  
MICHAEL J. A. LING

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(i).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

## Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.  
☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:

Small Entity Status Statements

U.S. APPLICATION NO. (if known) <b>09/701217</b>		INTERNATIONAL APPLICATION NO. PCT/GB99/01671		ATTORNEY'S DOCKET NUMBER 1926-00069	
17. The following fees are submitted: <b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b> Search Report has been prepared by the EPO or JPO..... \$ 860.00 International preliminary examination fee paid to USPTO (37 CFR 1.482).... \$ 690.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2))..... \$ 710.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... \$ 1,000.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)..... \$ 100.00  ENTER APPROPRIATE BASIC FEE AMOUNT -				\$860.00	
Surcharge of \$130.00 for furnishing the National fee or oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 Months from the earliest claimed priority date (37 C.F.R. 1.491(3)).				+	
Claims	Number Filed	Number Extra	Rate		
Total Claims	16 - 20 =		x \$ 9.00		
Independent Claims	2 - 3 =		x \$ 40.00		
Multiple dependent claim(s) (if applicable)		+ \$270.00			
TOTAL OF ABOVE CALCULATIONS =				\$860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28).				-430.00	
SUBTOTAL =				\$430.00	
Processing fee of \$130.00 for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)).					
TOTAL NATIONAL FEE =				\$430.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property +					
TOTAL FEES ENCLOSED =				\$430.00	
				Amount to be	
				Charged:	
a. <input checked="" type="checkbox"/> A check enclosed in the amount of \$ <u>430.00</u> to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. <u>01.2000</u> in the amount of \$ <u>      </u> to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>01.2000</u> . A duplicate copy of this sheet is enclosed.					
<b>NOTE:</b> Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:		ANDRUS, SCEALES, STARKE & SAWALL, LLP 100 East Wisconsin Avenue, Suite 1100 Milwaukee, Wisconsin 53202			
		Signature <i>Thomas M. Wozny</i>		Date <i>11/27/00</i>	
		Thomas M. Wozny		28,922	
		Name		Reg. No.	

520 Rec'd PCT/PTC 27 NOV 2000

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <b>09/701217</b>	INTERNATIONAL APPLICATION NO. PCT/GB99/01671	ATTORNEY'S DOCKET NUMBER 1926-00069
CERTIFICATE OF EXPRESS MAIL		
I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as EXPRESS MAIL-POST OFFICE TO ADDRESSEE, in an envelope addressed to: BOX PCT, COMMISSIONER OF PATENTS AND TRADEMARKS, WASHINGTON, D.C. 20231 on the <u>27<sup>th</sup></u> day of November, 2000. Express Mail Label <u>EL582777486US</u> .		
Jo Ann Kuczynski		
Name	Reg. No.	
<u>Jo Ann Kuczynski</u>	<u>11-27-00</u>	
Signature	Date	

Attorney's Docket No. 1926-00069Applicant or Patentee: Michael John Archer LING

Serial or Patent No.: \_\_\_\_\_

Filed or Issued: \_\_\_\_\_

For: \_\_\_\_\_

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(b))—INDEPENDENT INVENTOR**

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled GASIFIERS WITH NON RADIAL TUYERES

described in

☐ the specification filed herewith.☒ application serial no. PCT/GB99/01671 filed 27th May 1999☐ patent no. \_\_\_\_\_ issued \_\_\_\_\_

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

☐ no such person, concern, or organization☒ persons, concerns or organizations listed below\*

\*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention asserting to their status as small entities. (37 CFR 1.27).

FULL NAME Dedar Limited,ADDRESS 20 Balcombe Street, London NW1 6NB,Great Britain☐ INDIVIDUAL ☒ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so

(Small Entity—Independent Inventor [7-1]—page 1 of 2)

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made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Michael John Archer LING

Name of inventor

Signature of inventor

Date 21st November 2000

Name of inventor

Signature of inventor

Date

Name of inventor

Signature of inventor

Date

Attorney's Docket No. 1926-00069Applicant or Patentee: Michael John Archer LING

Serial or Patent No.: \_\_\_\_\_

Filed or Issued: \_\_\_\_\_

For: \_\_\_\_\_

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) and 1.27(e))—SMALL BUSINESS CONCERN**

I hereby declare that I am

- ☐ the owner of the small business concern identified below:
- ☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN Dedar Limited

ADDRESS OF CONCERN 20 Balcombe Street, London NW1 6NB,  
Great Britain

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third-party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed, to and remain with the small business concern identified above with regard to the invention, entitled

GASIFIERS WITH NON RADIAL TUBESby inventor(s) Michael John Archer LING

described in

- ☐ the specification filed herewith
- ☒ application serial no. PCT/GB99/01671, filed 27th May 1999
- ☐ patent no. \_\_\_\_\_, issued \_\_\_\_\_

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below\* and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

\*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention avowing to their status as small entities. (37 CFR 1.27)

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

☐ INDIVIDUAL☐ SMALL BUSINESS CONCERN☐ NONPROFIT ORGANIZATION

(Small Entity—Small Business [7-4]—page 1 of 2)

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

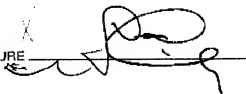
☐ INDIVIDUAL☐ SMALL BUSINESS CONCERN☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small business entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Michael John Archer LINGTITLE OF PERSON OTHER THAN OWNER DirectorADDRESS OF PERSON SIGNING "Eyston", Borley Green, Sudbury,  
Suffolk CO10 7AH, Great Britain

SIGNATURE



Date

21st November 2000.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application of ) CERTIFICATE OF EXPRESS MAIL  
)  
MICHAEL J. A. LING ) I hereby certify that this correspondence is  
) being deposited with the United States  
Int'l. Appln. No. PCT/GB99/01671 ) Postal Service, with sufficient postage, as  
) EXPRESS MAIL - POST OFFICE  
Int'l. Filing Date: 17 May 1999 ) ADDRESSEE, in an envelope addressed  
) to: Box PCT Application, Commissioner  
GASIFIERS WITH NON RADIAL ) for Patents, Washington, D.C. 20231 on  
TUYERES ) the 27<sup>th</sup> day of November, 2000. The  
) Express Label is EL582777486US.  
)  
) *JoAnn Kuczynski 11-27-00*  
) JoAnn Kuczynski Date

PRELIMINARY AMENDMENT

Milwaukee, Wisconsin 53202  
November 27, 2000

Box PCT Application  
Commissioner for Patents  
Washington, D.C. 20231

Sir:

It is requested that U.S. national stage examination be carried out on the amended claims dated July 26, 2000. Prior to computing the filing fee in this application, kindly amend the above identified application, as follows. The filing fee is to be computed on the amended claims.

IN THE ABSTRACT:

Cancel the Abstract presently in the application and substitute therefor the Abstract attached to this Preliminary Amendment.

IN THE SPECIFICATION:

Page 1, after the title and before the first line of text, insert the heading ---



BACKGROUND OF THE INVENTION---

Page 2, between lines 13 and 14, insert the heading ---SUMMARY OF THE INVENTION---

Page 4, between lines 16 and 17, insert the heading ---BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING---

Page 4, between lines 29 and 30, insert the heading ---DETAILED DESCRIPTION OF THE INVENTION---

IN THE CLAIMS:

Claim 4, line 1, delete "or claim 3"

Claim 5, line 1, delete "any of the preceding claims" and substitute therefor ---  
claim 1---

Claim 6, line 1, delete "any of the preceding claims" and substitute therefor ---  
claim 1---

Claim 8, line 1, delete "any of the preceding claims" and substitute therefor ---  
claim 1---

Claim 9, line 1, delete "any of the preceding claims" and substitute therefor ---  
claim 1---

Claim 13, line 1, delete "or claim 12"

Add the following claims.

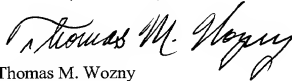
14. A method as claimed in claim 12, wherein the air is drawn through the tuyeres by reducing the pressure at the producer gas outlet of the gasifier.

15. A gasifier as claimed in claim 3, wherein said axis of projection of each tuyere is directed upwardly of the chamber in addition to being directed with its axis at an acute angle to a tangent of the wall when projected on a horizontal plane containing that tuyere.

16. A gasifier as claimed in claim 7, wherein said tuyeres are distributed substantially uniformly around said chamber and each said tuyere includes a nozzle which projects through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about said axis of the tuyere.

Respectfully submitted,

ANDRUS, SCEALES, STARKE & SAWALL, LLP



Thomas M. Wozny  
(Reg. No. 28,922)

100 East Wisconsin Avenue, Suite 1100  
Milwaukee, Wisconsin 53202  
(414) 271-7590  
Atty. Docket No. 1926-00069

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GASIFIERS WITH NON RADIAL TUYERES

This invention relates to gasifiers and in particular to improvements in or relating to gasifiers whereby improved combustion may take place therewithin. The invention further relates to a method of operating a gasifier.

- 5 The production of producer gas (a mixture of about 30% carbon monoxide and 70% nitrogen, though other gases may also be present) is usually performed with a so-called gasifier, in which pyrolysis is performed. The gasifier comprises a chamber provided with air inlets in such a way that the burning of fuel within the chamber take place under controlled conditions.
- 10 Originally, gasifiers used coal or coke as a fuel source, but interest in gasifiers has recently increased since they may be used for the disposal of various kinds of waste organic solid matter whilst yielding producer gas, which in turn may drive a combined heat and power unit, to yield both heat and electricity. Thus, the solid fuel may typically comprise wood or wood
- 15 derivatives, straw, poultry litter, dried sewage sludge and refuse-derived combustible material, to mention but a few.

- In a gasifier chamber, the solid fuel is reduced to a bed of carbon at a temperature of above 1000°C, a stream of air being passed through the bed with the combustion conditions set so that the oxygen in the air combines
- 20 with the carbon to form carbon monoxide. Other gases such as methane and hydrogen may also be produced, depending upon the chemical composition of the fuel employed.

- A product of the combustion in a gasifier is ash, but this is of relatively low density and of small volume compared to the solid fuel supplied to the
- 25 gasifier. It is consequently relatively easy to dispose of, especially since it is wholly sterile. By contrast, the producer gas may be used for a variety of purposes, though since it is toxic in view of the carbon monoxide content, it must nevertheless be treated with care. For example, the collected producer gas may immediately be used in an internal combustion engine for the
- 30 generation of electricity, without being stored for long periods or otherwise handled.

Though the principle upon which a gasifier operates is well known and understood, it is important that the combustion conditions are closely

AMENDED SHEET

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controlled in order that the production of carbon monoxide is optimised and that the carbon dioxide content of the producer gas is minimised. It has now been established that by controlling the actual introduction of air into the oxidation zone of a gasifier, it is possible to improve the gasifier  
5 performance, so increasing the overall efficiency of plant using this equipment.

Gasifier designs have been proposed in NL-A-8900939 and CH-A-237348. In both of these prior designs, arrangements are made to introduce combustion air into a gasifier in such a way that the air is not  
10 directed strictly radially with respect to the axis of the combustion chamber, in an attempt to enhance combustion within the chamber. The present invention stems from attempts further to improve the production of producer gas.

According to one aspect of the present invention, there is provided a  
15 gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber for the introduction of air into the combustion chamber, each such tuyère defining an axis along which air is projected into the chamber, at least some of the  
20 tuyères being configured to impart a rotational motion about said axis along which the air is projected into the chamber from each such tuyère, whereby the combustion air is projected in the form of a jet stream which swirls about the length of the stream.

Preferably, at least some of the tuyères are disposed with their  
25 respective axes at an acute angle (when projected on to a horizontal plane containing the respective tuyère) to a tangent to the wall of the chamber at the location of that tuyère, the axis of projection of each said tuyère being in the same sense with respect to the axis of the chamber, whereby the projected air also tends to swirl around the chamber.

It will be appreciated that the gasifier of this invention is able to  
30 achieve better reduction of the fuel, by improving the interaction between the introduced air and the hot carbonised bed at the bottom of the gasifier chamber. This interaction may be achieved either solely by causing the

introduced air to rotate along the axis of projection into the gasifier, or by additionally causing the introduced air to swirl around the lower region of the chamber. By adopting both of these measures of this invention, the interaction of the air with the bed at the bottom of the gasifier is much enhanced, so giving better control of the combustion of the fuel. In turn, this leads to more complete combustion in the oxidation zone, giving a greater oxygen deficiency in the reduction zone and raising the proportion of carbon monoxide in the resultant producer gas.

Most preferably, all of the tuyères lie at substantially the same acute angle to the chamber wall where the respective tuyère projects therethrough. Thus, by having the angle of projection of each said tuyère in the same sense with respect to the axis of the chamber, the introduced air tends to swirl around the chamber interacting with all portions of the relatively hot carbon bed. This effect is enhanced by providing the tuyères in a uniform distribution equi-spaced around the chamber.

Advantageously, each tuyère is directed both at a non radial angle to the axis of the chamber and also upwardly of the chamber. In this way, penetration of the entire hot carbon bed by the introduced air may be assured.

The chamber may be of general circular cross-sectional shape, at least in the region of the tuyères, with the axis of the chamber extending generally vertically. That chamber may have a lower wall of a generally conical shape and which supports a bed of the combustible material, said tuyères being mounted in that lower conical wall. At the other end of the chamber, there may be provided an inlet orifice for combustible material, the upper portion of the chamber serving as a hopper for the material loaded thereinto. The inlet orifice advantageously is fitted with a slide valve, to permit charging of the hopper whilst the gasifier is in operation.

Each tuyère is preferably in the form of a nozzle projecting through the chamber wall, the bore of the nozzle being configured to cause the air flow therethrough to rotate about its length. This may be achieved by providing an insert within each said nozzle, the insert comprising a plate the width of

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which is substantially the same as the nozzle internal diameter and the plate being twisted along its length.

This invention extends to a method of operating a gasifier for the production of producer gas from combustible material, which gasifier  
5 comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the combustion chamber through the tuyères and each tuyère is configured to impart a rotational motion about the axis of introduction of the air so that the combustion air is projected in the form of a  
10 jet stream which swirls about the length of the introduced stream. In addition, the invention provides for the air being introduced through tuyères at least some of which have their respective axes at an acute angle (when projected onto a horizontal plane containing the respective tuyère) to a tangent to a wall of the chamber at the location of that tuyère, whereby the  
15 air will tend to swirl around the chamber, simultaneously with the rotation of the air about its own axis.

By way of example only, one specific embodiment of gasifier constructed and arranged in accordance with the present invention will now be described in detail, reference being made to the accompanying drawings  
20 in which:

Figure 1 is a diagrammatic vertical section through the embodiment of the gasifier;

Figure 2 is a plan view on the lower wall of the gasifier chamber shown in Figure 1, with parts removed for clarity;

25 Figure 3 is a detailed view on an enlarged scale through said lower wall;

Figure 4 is an end-view on a tuyère of the gasifier of Figures 1 to 3; and

Figure 5 illustrates an insert plate of the tuyère nozzle of Figure 4.

30 Referring initially to Figure 1, there is shown diagrammatically an embodiment of gasifier arranged for the production of producer gas from a solid combustible material serving as a fuel, such as wood chippings, logs, coal or similar materials, poultry litter, dried sewage sludge or a refuse

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derived fuel. The gasifier comprises a combustion chamber 10 having a generally conical lower wall 11 provided with a flange 12 around its upper periphery. A hopper 13 has a corresponding flange 14 at its lower periphery and which is secured by bolts (not shown) to flange 12 of the lower wall 11.

- 5 The upper end of the hopper 13 is closed by a slide valve assembly 15, which permits recharging of the hopper with more solid fuel whilst operation of the gasifier continues. An actuator 15A is mounted to one side of the hopper, to effect opening and closing of the slide valve assembly.

- 10 In an alternative arrangement (not shown) the hopper has a simple lid which may be secured in position and a fuel feed arrangement may be provided to supply fuel into the upper part of the hopper.

The lower wall 11 is carried on a base structure 16 which defines a plenum chamber 17 provided with an air inlet 18 and six lighting ports 19, each normally closed by a respective cap 20, the ports 19 being equi-spaced around the plenum chamber 17. The central region of the lower wall 11 communicates through opening 22 with a tube 23 within which the producer gas is formed during operation of the gasifier, the tube 23 leading to a lower chamber 24. A producer gas outlet pipe 25 passes through an outer wall 26 of the lower chamber 24 and there is provided a port 27 to that chamber, normally closed by a blanking plate 28 but through which access to the chamber may be gained for example for ash removal and servicing.

An automated ash removal system is fitted below the tube 23. This comprises an eccentric grate assembly 40 mounted on a shaft 41 rotatably supported below the base wall of the lower chamber 24. The shaft 41 also carries a scraper bar 42 having chains which serve to plough collected ash into a discharge chute 43 below lower chamber 24. A motor 44 is drivingly connected by chain 45 to the shaft 41 to effect rotation of both the grate assembly 40 and the scraper bar 42. A discharge auger 46 takes discharged ash from the chute 43, through a water seal provided at the bottom of that chute.

Air enters the plenum 17 through inlet 18 and passes into the combustion chamber 10 through a plurality of tuyères 30, provided in the conical lower wall 11 of the chamber. As best seen in Figure 2, six such tuyères 30 are provided, equi-spaced around the opening 22 in alignment with the lighting ports 19. The tuyères all lie at substantially the same angle to the vertical axis 31 of the combustion chamber 10 and also all lie at substantially the same angle to a horizontal radius of the chamber intersecting the respective tuyère. Thus, air entering the combustion chamber will tend to swirl around the chamber in a counter-clockwise direction and at the same time to rise upwardly within the chamber.

Each tuyère 30 is fitted with an insert 33 so as to impart a spin on the jet of air issuing from the tuyère into the combustion chamber 10. The insert is in the form of a plate having a width substantially equal to the diameter of the tuyère, as shown in Figure 4, and is twisted through 90° along its length.



In this way, the air passing through the tuyère will be caused to swirl about the axis of the tuyère.

In operation, solid fuel pieces are loaded into the hopper 13 through the slide valve assembly 15 and then the air flow is commenced by reducing the pressure at the producer gas outlet 25. This draws air through inlet 18 into the plenum 17, the air then swirling around that plenum 17 and assisting cooling of the lower plate 11, when operation of the gasifier has been established. From the plenum 17, the air is drawn through the tuyères 30 into the bed on the lower wall 11 and down through opening 22, tube 23 and into the lower chamber 24 by the reduced pressure at the producer gas outlet 25. The gasifier is lit through at least one of the ports 19, for example with a gas torch, and the combustion within the chamber 10 is established. When fully operational, the upper region 35 of the gasifier will be at around 500° C and will serve as a distillation zone for high molecular weight hydrocarbons. Below that, there is a carbonisation zone 36 operating at around 600° C, where the solid fuel is converted to charcoal, by burning off other matter. On and immediately above the lower wall 11, there is established an oxidation zone 37, operating at around 1200° C, where the carbon is burned in air to form CO<sub>2</sub>. The hot carbon then falls through opening 22 into tube 23 and on to grate 40, there being a deficiency of oxygen in the tube 23 to continue the combustion of the carbon and so a reduction process takes place, reducing the CO<sub>2</sub> to CO. The final producer gas mixture leaves the lower chamber 24 through pipe 25.

During operation of the gasifier, the motor 47 is operated intermittently slowly to drive the grate assembly 40. The eccentricity of this assembly grinds any large pieces which then fall through the lower chamber 24 and are ploughed into the discharge chute 43. The motor may be operated continuously, depending upon the ash content of the fuel source.

A typical producer gas composition obtained from using wood as a fuel source may be as follows:

<u>GAS</u>	<u>% by weight</u>
Nitrogen	45-54
carbon monoxide	18-25
hydrogen	13-15
water vapour	10-15
carbon dioxide	5-10
methane	3-5

- By adopting the measures as described above concerning the disposition of the tuyères and also the internal configuration thereof, and so improving the introduction of air into the oxidation zone through the tuyères,
- 5 it is found the carbon dioxide content may significantly be reduced, with a consequent improvement in the carbon monoxide content of the producer gas.

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## CLAIMS

1. A gasifier for the production of producer gas from combustible material, comprising a chamber into which said material is introduced and a  
5 plurality of tuyères disposed at or adjacent the lower end of the chamber for the introduction of air into the combustion chamber, each such tuyère defining an axis along which air is projected into the chamber, at least some of the tuyères being configured to impart a rotational motion about said axis along which the air is projected into the chamber from each such tuyère,  
10 whereby the combustion air is projected in the form of a jet stream which swirls about the length of the stream.
2. A gasifier as claimed in claim 1, wherein at least some of the tuyères are disposed with their respective axes at an acute angle (when projected on to a horizontal plane containing the respective tuyère) to a tangent to the wall  
15 of the chamber at the location of that tuyère, the axis of projection of each said tuyère being in the same sense with respect to the axis of the chamber, whereby the projected air also tends to swirl around the chamber.
3. A gasifier as claimed in claim 2, wherein said at least some of the tuyères lie at substantially the same acute angle to the respective tangents to  
20 the chamber wall at the location of the respective tuyères.
4. A gasifier as claimed in claim 2 or claim 3, wherein said axis of projection of each tuyère is directed upwardly of the chamber in addition to being directed with its axis at an acute angle to a tangent of the wall when projected on a horizontal plane containing that tuyère.
- 25 5. A gasifier as claimed in any of the preceding claims, wherein all of said tuyères are similarly configured and disposed with respect to the chamber.
6. A gasifier as claimed in any of the preceding claims, wherein the chamber is generally of circular cross-sectional shape at least in the region  
30 of the tuyères with the axis of the chamber extending generally vertically.
7. A gasifier as claimed in claim 6, wherein the gasifier chamber has a lower wall of generally conical shape which supports a bed of the combustible material, said tuyères being mounted in the lower wall.

8. A gasifier as claimed in any of the preceding claims, wherein said tuyères are distributed substantially uniformly around the chamber.

9. A gasifier as claimed in any of the preceding claims, wherein each said tuyère includes a nozzle which projects through the chamber wall, the  
5 bore of the nozzle being configured to cause the air flow therethrough to rotate about said axis of the tuyère.

10. A gasifier as claimed in claim 9, wherein an insert is provided within each said nozzle, the insert comprising a plate the width of which is substantially the same as the nozzle diameter and the plate being twisted  
10 along its length.

11. A method of operating a gasifier for the production of producer gas from combustible material, which gasifier comprises a chamber into which said material is introduced and a plurality of tuyères disposed at or adjacent the lower end of the chamber, in which method air is introduced into the  
15 combustion chamber through the tuyères and each tuyère is configured to impart a rotational motion about the axis of introduction of the air so that the combustion air is projected in the form of a jet stream which swirls about the length of the introduced stream.

12. A method as claimed in claim 11, wherein the tuyères are disposed  
20 with their respective axes at substantially the same acute angle (when projected onto a horizontal plane containing the respective tuyère) and in the same sense to a tangent to a wall of the chamber at the location of that tuyère whereby air introduced to the chamber through the tuyères tends to swirl around the chamber.

25 13. A method as claimed in claim 11 or claim 12, wherein the air is drawn through the tuyères by reducing the pressure at the producer gas outlet of the gasifier.

## ABSTRACT OF THE DISCLOSURE

A gasifier for the manufacture of producer gas has a chamber (10) for the combustion of material, the chamber (10) being provided with a plurality of tuyeres (30) for the introduction of combustion air to the chamber. The tuyeres (30) are disposed at an acute angle to the wall of the chamber (10) so that air is directed both around and upwardly of the chamber. Each tuyeres (30) is configured to produce a jet stream wherein the air swirls along the length of the stream.

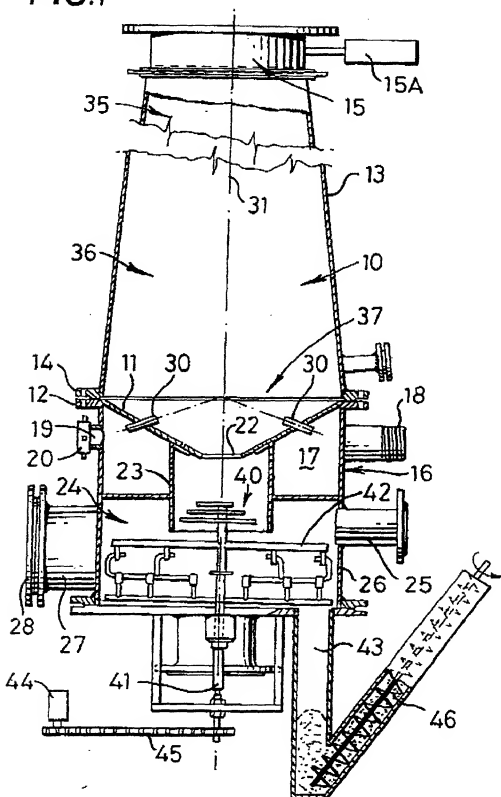
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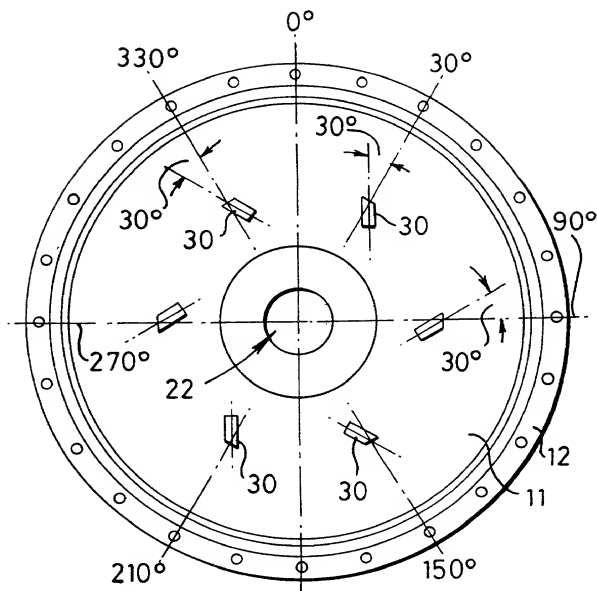
FIG.1

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FIG.2

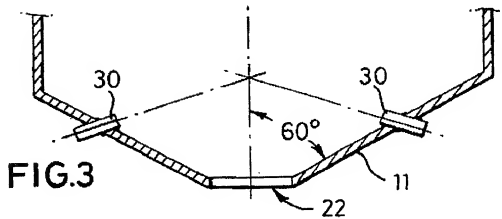
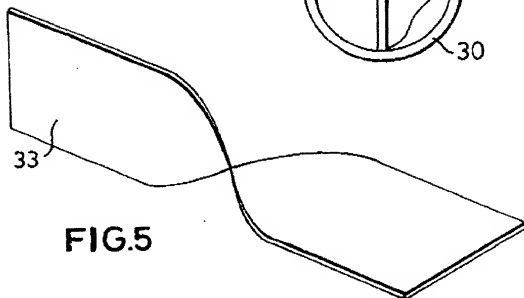
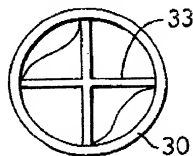


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**FIG.4**



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My residence, post office address, and citizenship are as stated below next to my name.					
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As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Name	Registration Number	Name	Registration Number
Glenn O. Starke	17,031	Edward R. Williams, Jr.	36,057
Eugene R. Sawall	17,431	Joseph D. Kuborn	40,689
Daniel D. Fetterley	20,323	William K. Baxter	41,606
George H. Solveson	25,927	William L. Falk	27,709
Gary A. Essmann	29,376		
Thomas M. Wozny	28,922		
Michael E. Taken	28,120		
Joseph J. Jochman, Jr.	25,058		
Andrew S. McConnell	32,272		

☐ Additional attorney(s) and/or agent(s) named on a supplemental sheet attached hereto.

☒ Please direct all correspondence to: Name Thomas M. Wozny, Reg. No. 28,922

Address Andrus, Sceales, Starke & Sawall, LLP

Address 100 East Wisconsin Avenue, Suite 100

City Milwaukee State Wisconsin

Country United States Telephone (414) 271-7390 Zip 53202-4178

Fax (414) 271-5770

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])

Family Name or Surname

Michael John Archer

LING

Inventor's

Signature

Date

21st November 2000

RESIDENCE: City

State

Country

GB

Citizenship

British

POST OFFICE ADDRESS

"Eveston", Borley Green, Sudbury, Suffolk

City

State

Zip

CO10 7AH

Country

GB

☐ Additional inventors are being named on supplemental sheet(s) attached hereto.